# (12) UK Patent Application (19) GB (11) 2 178 608 A

(43) Application published 11 Feb 1987

(21) Application No 8614433

(22) Date of filing 13 Jun 1986

(30) Priority data
(31) 85104594 (32) 14 Jun 1985 (33) CN
86103856 5 Jun 1986

(71) Applicant
Yu Zhiwei,
No 1 Lane 92, Yong Nian Lu, Shanghai, Peoples Republic of China

(72) Inventor
Yu Zhiwei

(74) Agent and/or Address for Service
Marks & Clerk,
57–60 Lincoln's Inn Fields, London WC2A 3LS

(51) INT CL[4]
H02J 7/00 7/10 // H01R 13/62

(52) Domestic classification (Edition I):
H2H 25G BCA BCD BCH BCJ
H2E CCX
U1S 2078 2107 H2E H2H

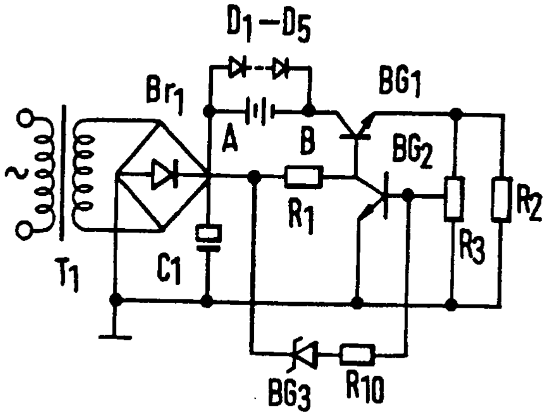
(56) Documents cited
GB A 2036473 GB 1252006 GB 0936969
GB 1603450 GB 1180168 EP A2 0005841
GB 1569860 GB 1176905 WO A1 79/01061
GB 1513443 GB 1156403 US 4539516
Wireless World Oct 1955 p503–504

(58) Field of search
H2H
Selected US specifications from IPC sub-class H02J

## (54) Recharging dry cell batteries

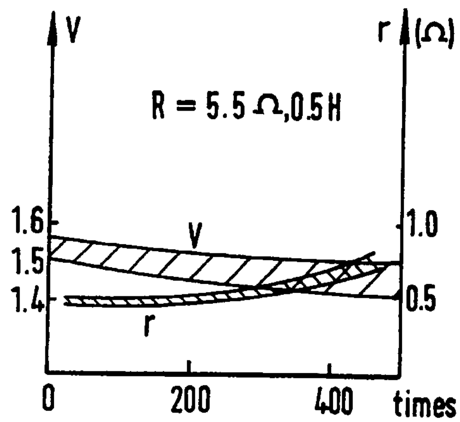
(57) A dry cell battery is repeatedly recharged soon (one to three days) after each discharge by a substantially constant current up to 1.1–1.33 times its nominal voltage. The charging current may be stabilized by means of a filament lamp in series and/or parallel with resistors, (Figs. 4, 5), or by a regulator having a transistor BG1 in series with the battery. Overcharging is prevented by a protection device in shunt with the battery; this device may be a zener diode or a string of silicon diodes D1 to D5. Additionally, charging current may be disconnected in response to battery voltage by means of a relay having a coil in parallel with the battery and contacts in series with the battery, or by a zener diode BG3 causing transistor BG1 to turn off. The battery charger may be coupled to an appliance powered by the battery using connectors held together by magnets (Figs. 6, 7).

FIG.3.

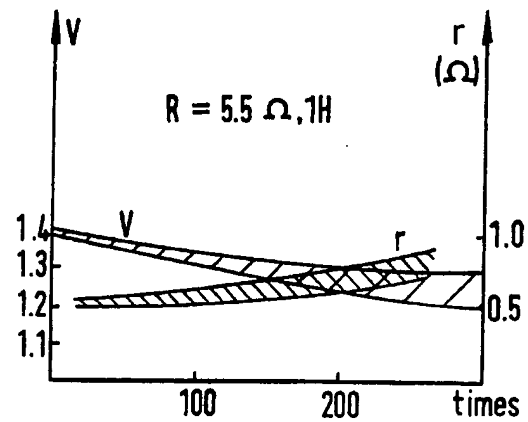



GB 2 178 608 A

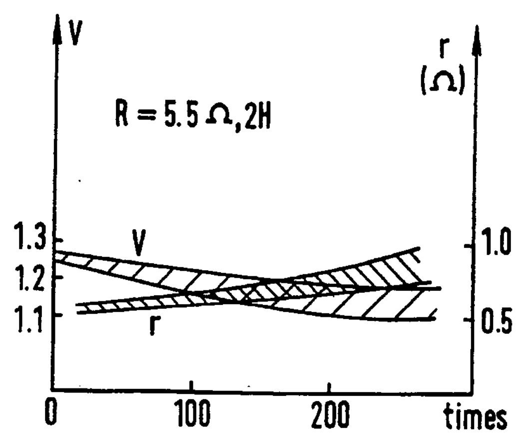
The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.




F I G.1a.




F I G. 1b.




F I G.1c.

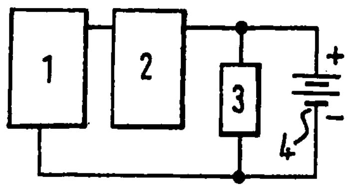



FIG.2.

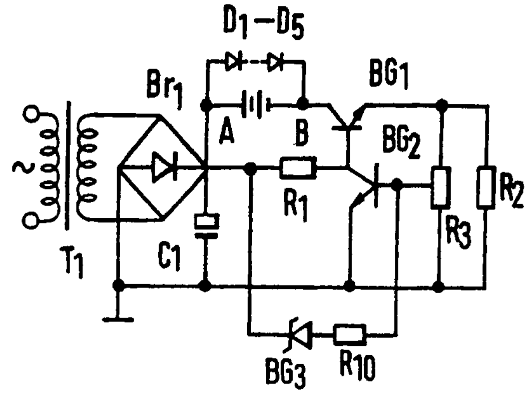



FIG.3.

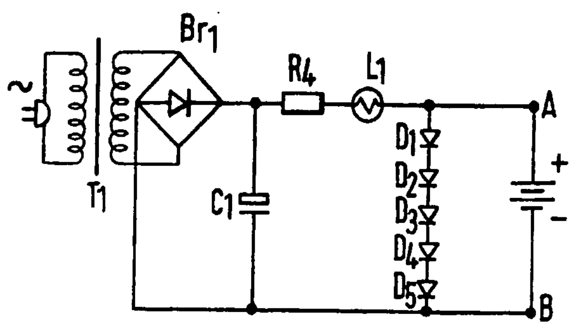



FIG.4.

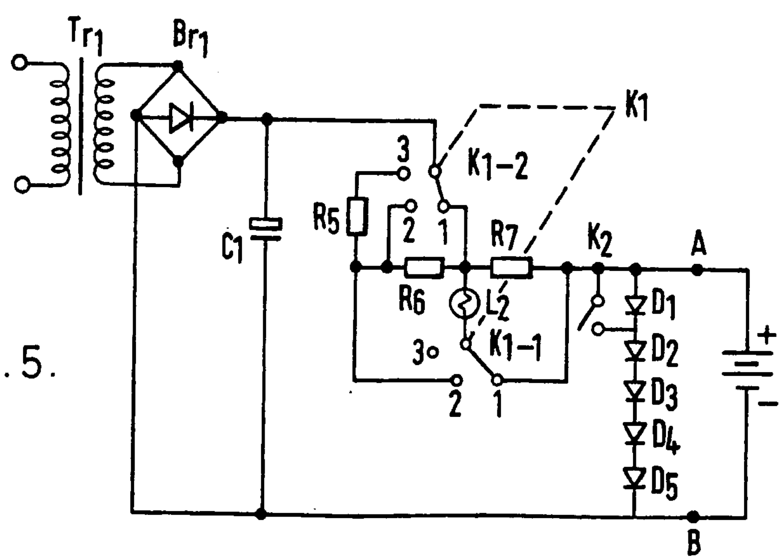



FIG.5.

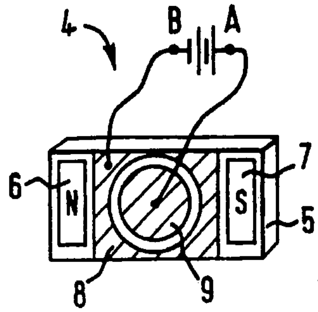



FIG.6a.

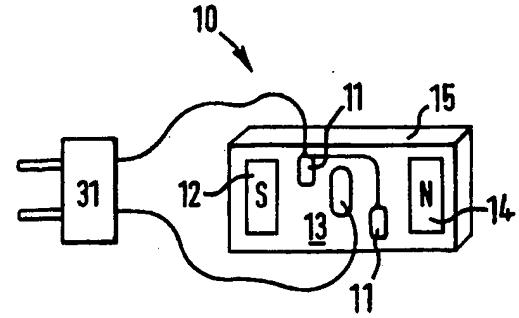



FIG.6b.

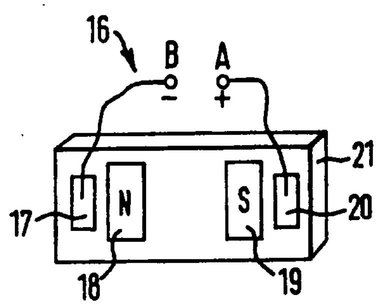



FIG.7a.

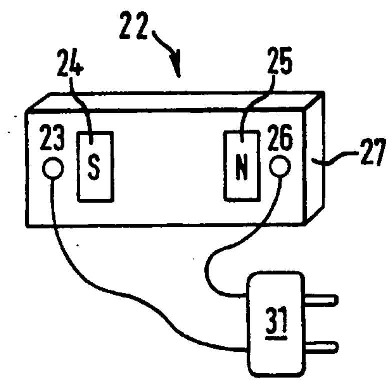
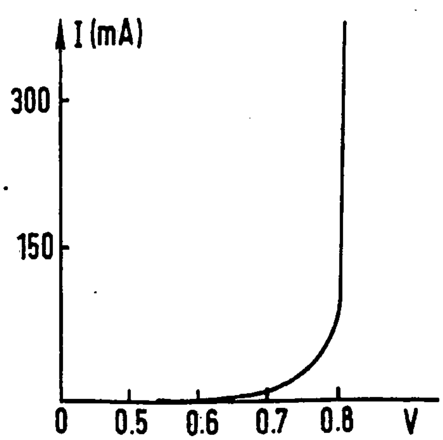



FIG.7b.

FIG.8.



SPECIFICATION

**Recharging dry cell batteries**

This invention relates to a dry cell battery reactivator, particularly to a process and device for recharging a dry cell battery in order to enchance its operating life.

A dry cell battery is a primary battery. One kind of dry cell battery is a Zn-Mn battery, which has the advantages of easy application, reliable performance, low cost and portability. However, the major setback of dry cell batteries is their short operating life, especially when applied to heavy power-consuming electrical appliances, such as cassette tape recorders, such that not only is the voltage reduced, but the internal resistance of the battery also increases, and frequent replacement is required. It has been considered hitherto that a dry cell battery could not be recharged. It is also noted, in the Electrician Handbook, published in Japan, that a primary cell battery could not be recharged because this would lead to risk of destruction of the battery. In Japapese patent application NO. 55-500324 (PCT application) published on June 5, 1980, a method and device for recharging a dry cell battery was disclosed, wherein the positive half-cycle of A.C. is used as a charging pulse, whilst the negative half-cycle of the same is used for a smaller discharging pulse of the dry cell battery, with a result that the dry cell battery could be recharged as many as fifty times and could be used in a transistor radio or cassette tape recorder.

However, in view of further improving the dry cell battery's recharge performance it is the object of the present invention to provide a process and device that enables considerable improvement of dry cell battery rechargability, say up to two hundred times or more, in order to significantly enhance its operating life without effecting its usability.

The process provided in the present invention is that charging is carried out by using a generally constant D.C. up to an ampere hour value basically equal to the ampere-hour capacity of the discharged battery in a comparatively short period after the dry cell battery is discharged. Charging in good time is important and only charging in good time and up to the ampere-hour capacity of the discharged battery, in order that the chemical reactions in the dry cell battery during discharge could be reversed.

Otherwise, once the gas and other chemicals produced during discharge were absorbed by other materials in the battery and firmly combined with them, it would be very difficult to discompose or reduce them again through charging of electric current. In comparison with intermittant recharging, charging with D.C. has the advantages of safe and quick charging with comparatively small current required.

In the present invention, there is also provided means to switch off the recharging as soon as the dry cell battery reaches a voltage 1.1 to 1.33 times as large as its nominal voltage value, as at this moment the charge ampere hour is basically equal to the capacity of the battery and such switching off would prevent overcharging the battery that might produce too much gas and bring about the battery s destruction and leakage. A recharged battery can be stored for quite a long time, such as one year.

For implementation of the above mentioned process, the present invention also involves a device which includes a rectifier device which consists of a supply transformer, rectifier and filter, a current stabilizer device connected in series between the said rectifier and an output terminal, and a protection device connected in parallel with the output terminal for shunting when the dry cell battery is sufficiently charged, to maintain a basically constant D.C. output for charging the dry cell battery.

A magnetic connector to facilitate use of the device for timely recharging is also provided in the present invention. It is used to connect the charging device with the dry cell battery placed in an associated electric appliance.

The benefit that can be obtained from the present invention includes considerable enhancement of the dry cell battery's operating life, simple construction of the device, low cost and easy connection.

Now the invention will be further described by way of example with reference to the accompanying drawings, in which:

Fig. 1 (i.e. Figs. 1(a), (b) and (c) are graphs of Zn-Mn batteries' voltages and internal resistance corresponding to the batteries recharging circulation numbers, wherein Fig. 1a is the characteristic curve of each time discharging with a load of resistance of 5.5Ω continuously for 0.5 hour; Fig. 1b is the characteristic curve of each time discharging with a load of resistance of 5.5Ω continuously for 1 hour; Fig. 1c is the characteristic curve of each time discharging with a load of resistance of 5.5Ω continuously for 2 hours;

Fig. 2 is a schematic diagram of the device provided by the present invention;

Fig. 3 is a schematic circuit diagram of a first embodiment of the present invention;

Fig. 4 is a schematic circuit diagram of a second embodiment of the invention;

Fig. 5 is a schematic circuit diagram of a third embodiment of the present invention;

Fig. 6 is a constructional schematic diagram of a type of magnetic connector;

Fig. 7 is a constructional schematic diagram of another type of magnetic connector; and

Fig. 8 is a current-voltage characteristic curve of a diode used for shunt protection.

The process of the present invention is to

charge a dry cell battery with basically constant D.C. in a relatively short period after the battery is discharged, preferably within three days after discharge, better still one day. Charging polarity is in reverse direction to the battery s normal discharge polarity and is switched off as soon as the voltage between the two terminals of the battery reaches 1.1 to 1.33 times as large as the nominal value of the battery voltage, otherwise, overcharging may cause leakage. The charging current is maintained basically constant in the range of 50mA to 2000mA. Too low a charging current will take longer charging time, whereas too high a charging current will tend to overheat and damage the dry cell battery. Battery of type A, for instance, is suitable to be charged with current at between 1 to 2A. Suitable currents for charging batteries of different capacities are as follows:- 0.2-0.5A, preferably 300 mA for dry cell battery No. 1 (type R20); 0.15/0.25-0.4A, preferably 200/300/280 mA for dry cell battery No. 2 (type R14); 0.15-0.3A, preferably 180 mA for dry cell battery No. 4 (type R10); 0.05-0.2A, preferably 75-150 mA for dry cell battery No. 5 (type R6). It can be seen from the above data that batteries of different capacities have their respective optimal charging current that may prevent them from such damage as internal shorting, gasification leakage, etc. It is important to charge the batteries sufficiently without overcharging that may cause damage. The general rule is to charge up to a charging ampere-hour basically equal to that of the discharge and then switch off. For this purpose, a precision overcharge protection is necessary, to prevent the voltage increase going beyond certain predetermined value, which for different batteries should be: 1.7-2V/ section for dry cell battery No. 1,; 1.7-1.0V/ section for dry cell battery No. 3 to No. 4; and 1.55-1.7V/ section for dry cell battery No. 5. The merit resulted from the present process is that the internal resistance (r) of the battery always remains less than 8 times the internal resistance (r) of the fresh one, even if it has been subjected to many times of recharge circulation. The variation of battery s voltage and internal resistance in relation to times of rechargable circulation is shown in Fig. 1, which is a case taken as an example in Zn-Mn battery No.1 (type R20), where the discharge load resistance is 5.5Ω, equivalent to discharge current of 250-270mA, while the initial internal resistance is 0.5Ω. Fig. 1a is the curve of each time continuously discharging for 0.5 hour and recharge on the same day after discharge. The number of recharging and discharging cycles can be up to 400 or more with internal resistance (r) increasing less than a one-fold i.e. from 0.5Ω to 1Ω, and the load voltage of the battery maintained at 1.4V or more. Fig. 1b is each time continuously discharging for 1 hour and recharging the same day with loaded voltage maintained at 1.2-1.3V or more and internal resistance (r) less than 0.7-lΩ, in which the number of recharge-discharge cycles is 200 or more. Fig. 1c is each time continuously discharging for 2 hours and recharging on the same day with loaded voltage maintained at 1.1V or more and internal resistance (r) less than 0.7-1Ω, in which the number of recharge-discharge cycles is 200 or more. In the case of a basic Zn-Mn battery, the results are much better than that of an ordinary (non-basic) Zn-Mn battery, i.e. the load voltage will be 0.1-0.2V higher, the internal resistance (r) less than 0.8Ω and the number of recharge-discharge cycles increases much more. In regard to batteries No. 1 and No. 2 applied to cassette tape recorders, an ordinary Zn-Mn battery can be used continuously for 1.5-2 hours per day without obvious change for at least 2-3 months, whereas in case of basic Zn-Mn battery, it can be used 3-5 hours per day for at least 6 months without obvious change. As for battery No. 5 applied to cassette tape recorders, an ordinary Zn-Mn battery can be used about 1-1.5 hours per day for at least one month without obvious change, whilst for the basic Zn-Mn battery, it can be used 2-4 hours per day for at least 1.5-2 months or more. With a new Zn-Mn battery used to power a 10 W tape recorder, speed slows down and sound quality deteriorates after 30 minutes. However, after reactivation by the process of the present invention, the said downgrading appears only after 40 minutes. The battery can be recharged at least 40-60 times, by retaining 85% of the rated operating hours. In case of a basic Zn-Mn battery, the recharge-discharge cycles are up to at least 80 times. Two sections of new Zn-Mn battery No. 1 used to drive a toy car can run, the first time, 16 minutes before stopping, but after reactivation by the process of the present invention, the toy car each time can run 25-28 minutes. Retaining 85% of the rated operating hours, the battery can be recharged 20-30 times or more and in case of basic Zn-Mn battery, the recharge-discharge cycles are up to at least 40-100 times. These facts all mean that the batteries are averagely renovated i.e. their ampere hour increased.

To implement the process, the present invention provides a device for applying the process to achieve the above mentioned results.

Fig. 2 is a schematic block diagram of the device, wherein rectifier device 1, current stabilizer device 2 and shunt protection device 3 are provided. The rectifier device 1 is to rectify the 220V A.C. main supply into the required D.C., which charges the battery 4 that is connected at output terminals A and B through the current stabilizer device. The charging current is basically constant and the shunt protection device 3 that is in parallel with the battery to be charged is connected between the output terminals A and B. When

the voltage between the terminals of the battery is low, the current flowing through the shunt protection device 3 is very small and whenever the battery is sufficiently charged, i.e. reaching 1.1-1.33 times as large as the nominal voltage value, the current flowing through the shunt protection device 3 significantly increases, greatly decreasing the current flowing into the battery. Thus the shunt protection is achieved. In addition to shunt protection device, interrupting protection device can also be incorporated to break the charging current when the voltage between the terminals exceeds the preset value.

Fig. 3 is a schematic circuit diagram of the charging device, where battery of 3V is taken as an example. The rectifier device consists of supply transformer T1, bridge rectifier Br1 and filtering capacitor C1. The shunt protection device consists of multiple crystal diodes in series, such as the 5 diodes shown in the drawing, and the current stabilizer device consists of voltage regulator transistor BG1, amplifier transistor BG2 and resistors R1, R2, R3, etc. The functioning of the current stabilizer device is that, when the charging current increases, the voltage on the resistors R3 and R2 increases as well and the voltage applied to the base-emitter of the amplifier BG2 is also increased, thus the collector current passing through R1 increases, causing the collector voltage of amplifier transistor BG2 i.e. the base voltage applied to the regulator transistor BG1 to be decreased. Thus the base current of voltage regulator transistor 1 is decreased, so that the collector current of the voltage regulator is also decreased, i.e. the charging current to the series battery is decreased, and thus current stabilization is achieved. On the contrary, if the charging current decreases, the circuit may increase it. By adjusting the potentiometer R3, the magnitude of the charging current can be regulated. The shunt protection of the crystal diodes D1-D5 that are connected in parallel with the charged battery depends for its function on each diode s current-voltage characteristic curve (see Fig. 8) and when the voltage applied to both terminals of the diodes is low, say 0.55-0.6V, the current passing through the crystal diodes will be very small, but exceeding that voltage value the current will be greatly increased. Appropriate selection of type (for instance 1N4001) of the crystal diode and the number to be series-connected will help to greatly increase the current passing through the series diodes.

At the moment the voltage of the battery reaches 1.1-1.33 times as large as the nominal value, the diodes conduct and thus protection is achieved. Obviously a zener diode can also be applied to the shunt protection device. However, since its characteristic curve at the rising section is rather steep, it is difficult to find an appropriate zener diode with the stable voltage required. In comparison, a crystal diode is easier to match and to put into production for the series. Moreover, the number to be included and the voltage are adjustable. In the circuit, there is a series circuit of zener diode DG3 and resistor R10 connected between the terminal A and the base of transistor BG2 for charged current interrupting after the battery is sufficiently charged. The functioning is that, when the voltage of the battery has not yet reached the preset value, the zener diode BG3 is non-conducting, but when the voltage of the battery reaches the preset value the zener diode DG3 conducts, causing the transistor DG2 to be saturated and the collector current of transistor BG2 to be increased, whereas its voltage, i.e. the base voltage of voltage regulator transistor BG1, is greatly decreased and thus the voltage regulator transistor BG1 is cut off. It is obvious that a relay (not shown) can also be parallel connected at the output terminals A and B to operate when the battery is charged to the preset value and its normally closed contact is series connected into the circuit of the charging current for interrupting the current and thus acting as an interrupting protection device similar to the series circuit of the above mentioned zener diode DG3 and resistor R10.

In Fig. 4, the rectifier device and the shunt protection device are similar to those shown in Fig. 3 while the current stabilizer device consists of series connection of resistor R4 and small bulb L1. This is the cheapest way to make the circuit that can act as current stabilizer as well. As shown in the diagram, if the battery to be charged is 3V, the rectified output voltage of about 20V can be applied, which is far higher than the battery s voltage and, therefore, the charging current will not vary too much but will be maintained basically constant. Moreover, as the resistance of the series connected small bulb (for instance 6.3V/0.3A) has a positive temperature coefficient, so the stabilization of the current is further ensured.

In Fig. 5 the rectifier device and the shunt protection device were similar to those in Fig. 4 but, to meet different charging requirements, a two-gang three-position coaxial switch K1, (K1-1 and K1-2) is incorporated. When the switch is set at position "1", the current stabilizer device becomes a parallel circuit of the resistor R7 and small bulb L2, producing a large charging current and using the small bulb L2 to participate in stabilizing the current. Thus it is suitable for application to charge a battery of relatively large capacity. When the switch K1 is set at position 2 , the current stabilizer device consists of parallel-connected resistor R6 and small bulb L2 and a series connected resistor R7. Thus the charging current is in a medium range with the small bulb L2 participating in stabilizing the current. When the switch is set at position "3", the current stabilizer device is formed by series

resistors R5, R6, R7 and now the total value of the resistance is at maximum, with the charging current rather small and basically constant. Thus it is suitable for charging a battery of relatively small capacity. Switch K2 can be used to short circuit the crystal diodes to meet the number of diodes required for charging the battery.

The small bulb L2 can be applied as a current stabilizer element as well as a pilot lamp. It is obvious that a D.C. galvanometer (not shown in the drawing) can also be included in the charging circuit for indication of the magnitude of the charging current.

Figs. 6a and 6b show a kind of handy magnetic connector provided to facilitate recharging to be carried easily. The first magnetic connector 4 (Fig. 6a) is to be fitted into the relative electric appliance adjacent to its batteries. The base plate 5 of the magnetic connector 4 can be made with insulation material, such as plastic, and there are two magnets 6 and 7 and two electrodes 8 and 9 made of metal conductor material on the base plate. The electrode 9 is in the form of a circle and located at the center, whereas the next electrode 8 is in the form of a ring, separated from the former but surrounding it. The electrodes 8 and 9 contact respectively the positive and negative poles A and B of the batteries in the electrical appliance. The polarities of the magnets 6 and 7 are opposite. For example, if magnet 6 is pole N, then magnet 7 will be pole S. To enhance the magnetism, a magnetic permeable soft iron can be attached on the back of the above said magnets. The second magnetic connector 10 is similar to the first one and on its base plate 15 there are also two magnets 12 and 14 (66B) which correspond to the magnets 6 and 7 of the first magnetic connector 4, but the polarities are in reverse, whilst electrodes corresponding to the electrodes 8 and 9 used as conductor devices are contact leads or springs 11 and 13, which are respectively contactable with the above-described charging device 31 embodying the invention that can be plugged into the power supply. To carry out charging, the charging device 31 is directly plugged into the supply socket and the second magnetic connector 10 is brought close to the first connector 1. Then, they will attract each other because their magnets are of opposite polarities. Thus a closed loop for charging current is formed for the charging operation. If the magnetic field of the magnets is strong enough, the attraction could work over a distance. Hence, attaching the magnetic connector on the appliance each time it has been switched off will immediately begin a reliable charging without delay and the cumbersome operation of dismounting the batteries or inserting charging plugs can be avoided. In Fig. 6, the conducting device, i.e. electrodes 8 and 9 of the first magnetic connector can also be connected to the charging device 31, and the conducting device 11 and 13 of the second magnetic connector to the batteries of the appliance, either one of the two magnetic connectors 4 and 10 can use magnets while another one uses soft iron substitutes, or uses a magnet and a soft iron substitute for each magnetic connector. The connection of two magnetic connector is fulfilled by the attraction between the magnet and the corresponding soft iron.

Fig. 7a shows the first magnetic connector 16 and Fig. 7b shows the second magnetic connector 22. The only difference from that shown in Fig. 6 is that the electrodes 17 and 20 of the first magnetic connector 16 are located respectively on both sides and the contact leads or springs 23 and 26 of the second magnetic connector 22 are correspondingly located on both sides and separated by a certain space to prevent a short circuit. By virtue of magnetic attraction of different polarities of magnets (10, 24; 19, 25), the charging source s polarities are protected against wrong connection. References 21 and 27 apply to the base plates of the first magnetic connector 16 and the second magnetic connector 22 respectively. Obviously, the conducting device may also have some variations in regard to positioning in accordance with the above concept and without disturbing the correct connection.

## CLAIMS

1. A process, which is to be used for reactivating dry cell battery in order to enhance its operating life, characterised in that: the recharging is carried out with basically constant D.C. up to an ampere-hour generally equal to the discharge ampere-hour in a comparatively short period after the battery is discharged.

2. A process as claimed in claim 1, characterised in that the dry cell battery being recharged is charged until its voltage reaches 1.1-1.33 times as large as its nominal value.

3. A process as claimed in claim 1, characterised in that the charging current is at a basically constant value within the range of 20-2000 mA.

4. A process as claimed in claim 1, characterised in that a short period after discharge is within three days, preferably one day.

5. A device, which is used to recharge a dry cell battery in order to enhance the battery's operating life, characterised in that it includes a recifier device (1), a current stabilizer (2) fitted between the said rectifier device and the output, and a shunt protection device (3) parallel connected with the output terminals.

6. A device as claimed in claim 5, characterised in that it includes a device to interrupt the charging current as soon as the voltage value of the battery is charged up to a preset value.

7. A device as claimed in claim 5 or 6, characterised in that the current stabilizer device includes a resistor in series with a small bulb.

8. A device as claimed in claim 5, 6 or 7, characterised in that the current stabilizer device includes a resistor in parallel with a small bulb.

9. A device as claimed in any one of claims 5 to 8, characterised in that the current stabilizer device includes a voltage regulator and an amplifier.

10. A device as claimed in any one of claims 5 to 9, characterised in that the said shunt protection device functions at the moment that the battery's voltage is charged to 1.1-1.33 times its nominal value.

11. A device as claimed in claim 10, characterised in that the said shunt protection device is formed by multiple crystal diodes in series.

12. A device as claimed in claim 10, characterised in that the said shunt protection device is a zener diode.

13. A device as claimed in any one of claims 5-12, characterised in that the said device is connected with the batteries in an appliance by magnetic connectors and at least one of the said connectors includes at least one magnet and two conducting devices.

14. A device as claimed in claim 13, characterised in that the two conducting devices (17, 20) are respectively located on both sides of the magnetic connector.

15. A device as claimed in claim 13, characterised in that one conducting device (8) locates around the next conducting device (9).

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1987, 4235.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.